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TETRAPOD FAUNA OF THE UPPER TRIASSIC (REVUELTIAN) OWL ROCK FORMATION, CHINLE GROUP, ARIZONA

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Abstract—The Owl Rock Formation, upper Chinle Group, crops out in the Four Corners area. In the 1980s, Kirby made an extensive collection of vertebrate fossils from the Owl Rock Formation in the Ward Terrace area, northeastern Arizona. We review the Owl Rock tetrapod fauna and refine the taxonomic assignments provided by previous workers. The Owl Rock Formation tetrapod assemblage thus consists of: metoposaurid amphibians, including the centra of cf. *Buettneria* sp. and *Apachesaurus* sp.; sphenodontids; kuhneosaurids; various indeterminate procolophonids, archosauromorphs and archosaurs; a variety of suchian reptiles, including cf. *Postosuchus*, *Postosuchus* sp., cf. *Poposaurus* sp. and shuvosaurids; the aetosaur *Typothorax coccinarum*; male and female morphs of the phytosaur *Pseudopalatus buceros*; and a coelophysoid. The presence of *P. buceros* and *T. coccinarum* in the fauna confirm the age of the Owl Rock fossil assemblage as Revueltian.

INTRODUCTION

The Owl Rock Formation is part of the upper portion of the Upper Triassic Chinle Group that crops out in northern Arizona, southern Utah and northwestern New Mexico. The tetrapod fauna of the Owl Rock Formation is considerable, but has never been formally published, except in very preliminary form (Kirby, 1989, 1991, 1993), as descriptions of singular taxa (Murry and Kirby, 2002; Fraser et al., 2005; Butler et al., 2006) or in larger review papers (Long and Murry, 1995; Heckert et al., 2005). In addition, these previous works (Kirby's in particular) are in serious need of updating, given the considerable changes in the taxonomy of Late Triassic tetrapods that have taken place since their publication (e.g., Long and Murry, 1995 and ensuing commentary in the literature). The tetrapod fossils discussed here are from localities along Ward Terrace, in the southwest portion of the Navajo Nation Indian Reservation, northeastern Arizona (Fig. 1). These localities provide the principal tetrapod fauna from the Owl Rock Formation. Here, we review previous studies conducted on the Owl Rock tetrapod fauna, provide our own analysis of the fauna and summarize the differences between the interpretation of previous workers and our own. In this paper, MNA refers to the Museum of Northern Arizona, Flagstaff.

PREVIOUS STUDIES

The history of modern study of the tetrapods from the Owl Rock Formation in Arizona is rather brief, due primarily to the majority of previous information deriving from a single worker, Randy E. Kirby. In two short papers (Kirby, 1989, 1993) and an extensive, unpublished master's thesis, Kirby (1991) provided the basis for our study. Later workers began to revise the fauna first documented by Kirby (1991), but only in piecemeal fashion (e.g., Murry and Kirby, 2002; Butler et al., 2002).

Kirby (1989) provided a preliminary summary of the Ward Terrace collecting area, regional stratigraphy, a depositional model and a faunal list. This faunal list included hybodontid sharks; palaeoniscid, colobodontid and coelacanthid fishes; metoposaurid amphibians; sphenodontid?, poposaurid? and sphenosuchian reptiles; the aetosaur *Typothorax*; two taxa of phytosaurs; and theropod and fabrosaurid dinosaurs. Kirby's (1991) thesis provided an expanded discussion of all the material that he listed previously. This thesis was more focused on the vertebrate fauna, presenting the taxonomy of all the specimens from the Owl Rock Formation in the MNA collection, as well as justification of his taxonomic assignments. This remains the only taxonomic discussion of the fauna. Kirby (1993) summarized the Late Triassic basin evolution of the Chinle Group depositional system and discussed faunal replace-

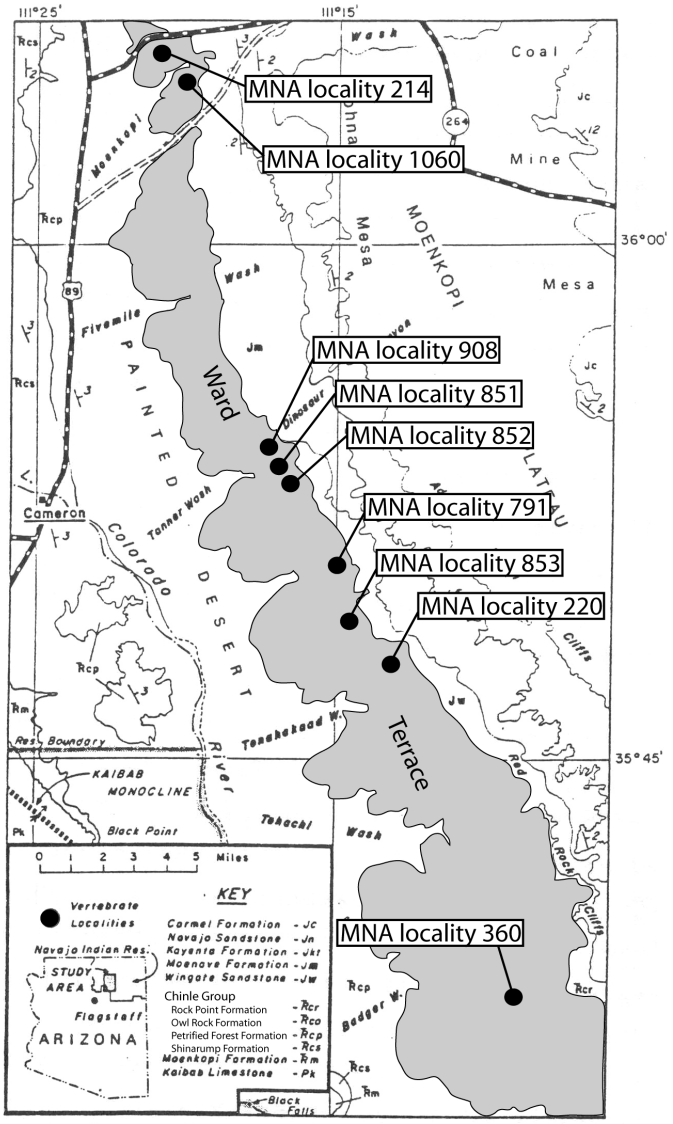

FIGURE 1. Regional map highlighting Owl Rock Formation outcrops (gray) and tetrapod fossil localities in the Ward Terrace collecting area. Modified from Kirby (1989, fig. 1).

ment events in light of this model. He also provided an updated faunal list for the Owl Rock Formation, further revised from Kirby (1991).

Relatively few studies have examined Owl Rock tetrapods since Kirby (1993). Murry and Kirby (2002) described a new genus and species of hybodont shark, *Reticulodus synergus*, from the Owl Rock Formation based on various isolated lateral teeth collected by Kirby during his thesis work. *Reticulodus* is also known from older specimens from stratigraphically lower strata in the Petrified Forest National Park collected by Murry (Murry and Kirby, 2002). Fraser et al. (2005) described a leptopleurine procolophonid, from the unit in the Abajo Mountains of southeastern Utah, based on an incomplete skull; this is the only tetrapod record from the Owl Rock Formation outside of Arizona.

Heckert (2001) briefly re-evaluated some of the putative prosauropod or ornithischian dinosaurs from Kirby's collection. This served as the basis for comparison with an unusual archosauriform tooth from Switzerland that is similar to the Owl Rock form, illustrated by Butler et al. (2006). Heckert et al. (2005) noted that the fauna documented by Kirby (1991) is indicative of a Revueltian age.

SYSTEMATIC PALEONTOLOGY

AMPHIBIA
TEMNOSPONDYLI
METOPOSAURIDAE
Metoposauridae indet.

Kirby (1991) assigned all amphibian material recovered from the Owl Rock Formation at Ward Terrace to cf. *Metoposaurus* sp. This material consists of cranial elements, pectoral girdle elements and various vertebral centra. Much of the material that Kirby (1991) referred to cf. *Metoposaurus* consists of isolated cranial fragments bearing the prominent "waffle-iron" sculpturing that is found on the skull and pectoral girdles of this family of Late Triassic amphibians (Hunt, 1993). Unfortunately, these cranial fragments do not include the lacrimal, a vital bone in order to discriminate genera and species within the Metoposauridae (Hunt, 1993). Thus, all material that we do not discuss separately below is considered Metoposauridae indet.; without the morphology of the lacrimal we cannot provide any finer taxonomic evaluation.

cf. *Buettneria*

MNA V1508 is a set of three relatively large centra (Fig. 2A-F). These centra are discoidal and pertain to a non-*Apachesaurus* metoposaur, most probably *Buettneria* (Hunt, 1993).

Apachesaurus sp.

MNA V5575 is a pair of small, elongate centra (Fig. 2G-L). This elongation of the centra is characteristic of *Apachesaurus* (Hunt, 1993). Thus, these specimens can be confidently assigned to *Apachesaurus* sp.

LEPIDOSAURIA
SPHENODONTIA
SPHENODONTIDAE
Sphenodontidae indet.

An isolated partial dentary (MNA V7056), an incomplete premaxilla? (MNA V7057) and six jaw fragments (MNA V7058-7063) were identified by Kirby (1991) as belonging to sphenodontids. Kirby (1991) found all eight of these specimens generally similar to *Clevosaurus hudsoni*, and he referred to them as "*Glevosaurus* [sic]." Harris et al. (1999) included these specimens in a preliminary analysis of sphenodontian diversity in the Chinle Group, but did not discuss them in detail. All specimens exhibit acrodont tooth implantation, hence Kirby's (1991) interpretation of them as sphenodontian, but they are all fragmentary – few preserve more than one reasonably complete tooth, and none are obviously referable to a known genus.

KUHNEOSAURIDAE
Kuhneosauridae indet.

Kirby (1993, fig. 2) listed abundant kuhneosaurid specimens from a single locality (MNA locality 360) in the Owl Rock Formation. However, specimens of this taxon are not discussed or noted in Kirby (1991)

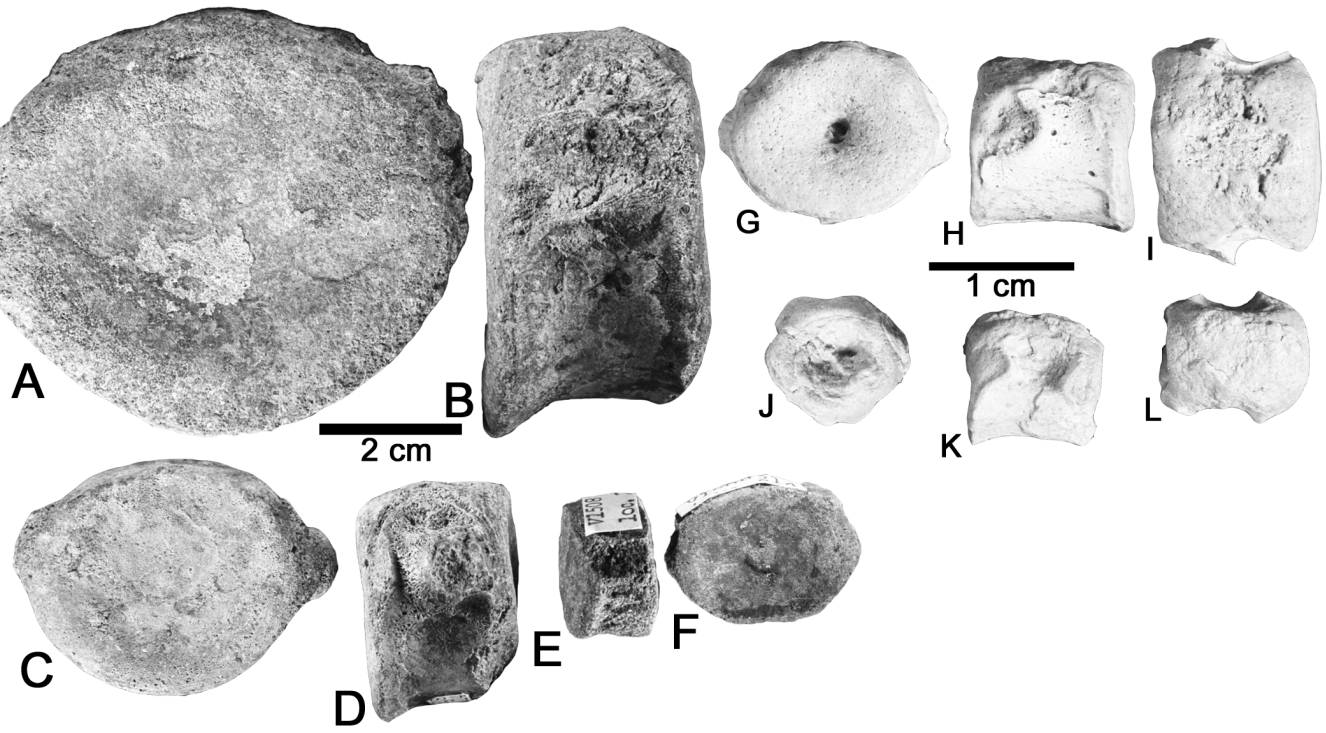

FIGURE 2. **A-F**, MNA V1508, *Buettneria* sp., centra in **A**, **C**, **F**, anterior and **B**, **D**, **E**, lateral views. **G-L**, MNA V5575, *Apachesaurus* sp., centra in **G**, **J**, anterior, **H**, **K**, lateral and **I**, **L**, dorsal views.

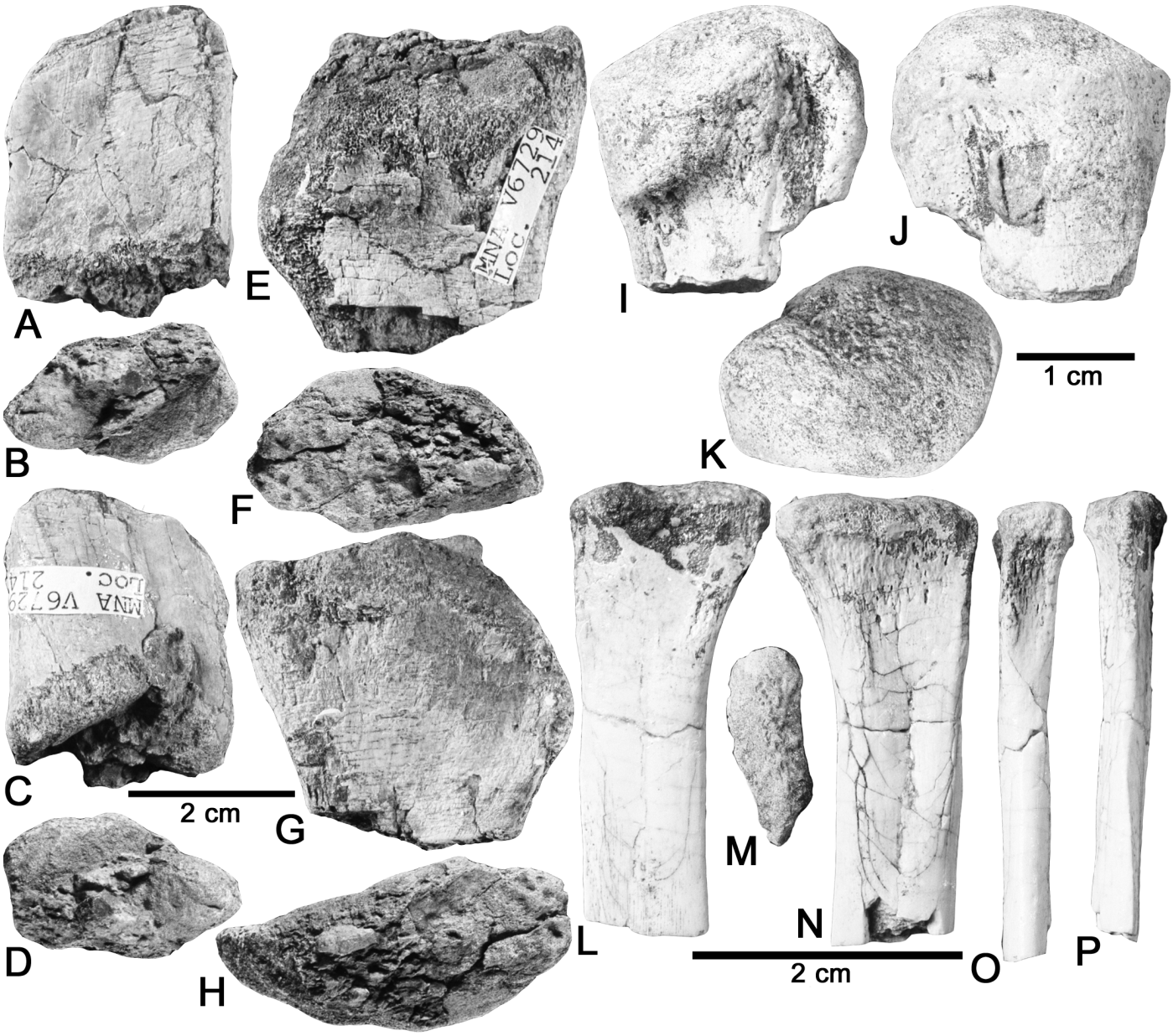

FIGURE 3. **A-D**, MNA V6729 (partim), Archosauromorph indet., bone fragment in **A**, anterior?, **B**, proximal?, **C**, posterior and **D**, distal views. **E-H**, MNA V6729 (partim), Archosauromorph indet., bone fragment in **E**, posterior?, **F**, proximal?, **G**, anterior and **H**, distal views. **I-K**, MNA 7240, Coelophysoidea indet., pathologic proximal right femur fragment in **I**, anterior, **J**, posterior and **K**, proximal views. **L-P**, MNA V7312, Archosauromorph indet., right? femur in **L**, anterior, **M**, proximal, **N**, posterior, **O**, medial and **P**, lateral views.

and were not found during our examination of the MNA collection. As such, there is no discussion, description or photographic documentation of these specimens. Thus, we include them for the sake of completeness but cannot corroborate Kirby's (1993) identification.

ARCHOSAUROMORPHA

Archosauromorpha indet.

Kirby (1993, fig. 2) listed, but did not discuss or illustrate, specimens that he referred to as Ornithischia? indet. from a single locality (MNA locality 853). Some of these were illustrated by Kirby (1991) in his master's thesis. Heckert (2001) described these teeth, noting that they have characteristics of both ornithischians and prosauropods, but are not definitively assignable to either taxon. Butler et al. (2006) demonstrated that at least some of the teeth described by Kirby (1991) are similar to a putative heterodontosaurid from the Upper Triassic of Switzerland that is not referable to Ornithischia and should instead be considered Archosauriformes *incertae sedis*.

During our examination of the MNA collection, we encountered a proximal limb fragment that was labeled as a femur of a Ornithischia? (Fig. 3L-P). This element is very rectangular in proximal view, with a ridge running down the posterior side of the shaft and a rectangular groove along the anterior side of the shaft. When comparing this supposed femur to femora of other basal ornithischians, we noted numerous differences, for example, the femoral head is not twisted as in ornithischians, the shaft is straight not bowed and there is no indication of a fourth trochanter (compare Fig. 3L-P with Norman et al., 2004, fig. 14.5a). Thus, we interpret this element as not pertaining to an ornithischian; and given its rectangular proximal end and straight shaft, we interpret the element as a fibula, not a femur. However, as a fibula it is rather non-descript, so we only identify it as an archosauromorph fibula.

Staurikosaurid? elements were reported, but not discussed, by Kirby (1993, fig. 2). While examining the MNA collection, we encoun-

tered two bone fragments, cataloged together, that were identified as Staurikosauridae? indet. (Fig. 3A-H). These appear to be limb elements, with one fragment (Fig. 3A-D) potentially being a distal tibia, given the offset of two surfaces on one end of the fragment (Fig. 3C). The other fragment appears to be a limb element given its elliptical cross-section, but cannot be interpreted further (Fig. 3E-H). Staurikosauridae (Colbert, 1970) is, of course, widely considered a junior subjective synonym of Herrerasauridae (Reig, 1963) (e.g., Langer, 2004). However, given Kirby's (1993) lack of justification for his interpretation and the poor quality of the specimens we assign them to Archosauromorpha indet.

RHYNCHOSAURIA

cf. Rhynchosauridae?

Kirby (1993) includes cf. Rhynchosauridae? in his faunal list of the Owl Rock, but did not discuss, describe or provide specimen numbers for this material. During on examination of the MNA collection, we were not able to identify any material assigned to cf. Rhynchosauridae?, thus, for the sake of completeness, we tentatively include this taxon in our revised faunal list, but cannot corroborate Kirby's (1993) identification of this material.

TRILOPHOSAURIDAE

"*Trilophosaurus*"

Kirby (1991) assigned an isolated incomplete tooth (MNA V7064), five posterior mandible fragments (MNA V7065-7069), two fragmentary quadrate condyles (MNA V7070-7071) and 82 quadrate condyles from bulk samples (MNA V7072-7074) to *Trilophosaurus* cf. *T. buettneri*. Heckert et al. (2006) and Spielmann et al. (2007) considered the isolated tooth to either belong to a procolophonid with similar tooth morphology (e.g., *Tricuspisaurus*) or to be screenwash contamination from previous workers, and thus an unsubstantiated record of *Trilophosaurus*. This interpretation is supported by the fact that this is the only record of *Trilophosaurus* from strata younger than mid-Revueltian and would also be the only Revueltian occurrence of *T. buettneri*, which has a current biostratigraphic range that extends from mid-Otischalkian to mid-Adamanian (Spielmann et al., 2007).

The other cranial material tentatively assigned to *Trilophosaurus* cf. *T. buettneri* includes undiagnostic fragments that, while sharing some features with *T. buettneri*, exhibit the following differences "[the lower jaw] possesses a comparatively deeper ventral border, more constricted cotylus, shallower adductor fossa, and less well-developed retroarticular process. The condyle likewise exhibits greater constriction, and a more attenuated attachment to the quadrate ramus" (Kirby, 1991, p. 246). The only feature that Kirby (1991) noted as a similarity between this material and *T. buettneri* is the quadrate condyle lacking a distinctive external pit. This does not provide a convincing argument to assign this material to *Trilophosaurus buettneri*, though, because there are more differences between this material and *T. buettneri* than similarities. Thus, there is no substantiated record of *Trilophosaurus buettneri* from the Owl Rock Formation. We refer the isolated tooth (MNA V7064) to Procolophonidae indet. and the mandible and quadrate fragments (MNA V7065-7069 and MNA 7070-7074, respectively) to Archosauromorpha indet.

ARCHOSAURIA

Archosauria indet.

MNA V5616 and V5617 are distal femora that Kirby (1991) identified as cf. *Postosuchus* sp. However, the U-shaped groove between the distal condyles indicates that these specimens pertain to either a theropod dinosaur or to a shuvosaurid archosaur, both of which have very similar distal femora. The lack of the crista tibiofibularis makes it difficult to assign these specimens to either group confidently, so we consider them Archosauria indet.

MNA V6731 is a series of three incomplete sacral centra that Kirby (1991) assigned to cf. *Postosuchus* sp. (Fig. 4A-B). Two of the three centra are fused, but, because of their poor preservation, that is all that can be distinguished about them. Three or more fused centra are found in rauisuchians (e.g., *Postosuchus*) and theropod dinosaurs (e.g., *Coelophysis*). With no additional characteristics to distinguish these specimens we refer them to Archosauria indet.

SUCHIA

cf. *Postosuchus* sp.

An extensive list of incomplete cranial and postcranial elements was given by Kirby (1991) as pertaining to cf. *Postosuchus* sp., including numerous elements that can now be assigned to various other related taxa given improvements in rauisuchian taxonomy since Kirby's evaluation (Long and Murry, 1995; Nesbitt and Norell, 2005; Lucas et al., 2007). Any specimens assigned by Kirby (1991) to this taxon that are not discussed elsewhere we still identify as cf. *Postosuchus* sp.

Postosuchus sp.

One specimen, a proximal left tibia fragment (MNA V5604), assigned to cf. *Postosuchus* sp. by Kirby (1991), is identical to the proximal tibia of *Postosuchus kirkpatricki* (Fig. 4U-Y). The proximal articulation of MNA V5604 has a triangular posterior half and a rectangular anterior half, just as in *P. kirkpatricki* (compare Fig 4U with Chatterjee, 1985, fig. 18b). However, the morphology of the tibia is not diagnostic of *P. kirkpatricki*, as interpreted by Chatterjee (1985) or Long and Murry (1995). So, given the close similarity but non-diagnostic nature of this specimen, we tentatively assign it to *Postosuchus* sp.

cf. *Poposaurus* sp.

Kirby (1991) identified a distal tibia (MNA V5605) as belonging to cf. *Postosuchus* sp. (Fig. 4R-T), but this specimen clearly demonstrates a posterior distal condyle that is well below the level of the anterior distal condyle. This feature is present in *Postosuchus*, *Poposaurus* and *Shuvosaurus*, but it is more prominent in *Poposaurus,* as in MNA V5605, so we identify this specimen as cf. *Poposaurus* sp.

SHUVOSAURIDAE

Shuvosauridae indet.

We note that there is no diagnosis of Shuvosauridae that currently encompasses all the specimens assigned to this family, so we use it provisionally to refer to the family of suchian reptiles that include *Shuvosaurus* (=*Effigia*) and *Sillosuchus* (Group X of Nesbitt, 2007). In addition, we follow Lucas et al. (2007) in considering *Shuvosaurus* to be the senior subjective synonym of *Effigia* and recognize that the genus *Shuvosaurus* has two species, *S. inexpectatus* and *S. okeeffeae*.

Two proximal tibia fragments (MNA V5602 and MNA V5603) that Kirby (1991) originally identified as cf. *Postosuchus* sp. are interpreted here as being the proximal tibiae of a shuvosaurid (Fig. 4L-N, Z-DD). The tibiae are subtriangular in proximal view with a proximal groove that overhangs the posterior margin. Overall, the specimens bear a resemblance to *S. okeeffeae* (compare Fig. 4L-N, Z-DD to Nesbitt, 2007, fig. 45), but because the MNA specimens are not identical to *S. okeeffeae*, the Owl Rock specimen having a more D-shaped proximal end and lacking a prominent ridge on its lateral surface, thus, we refer this maerial to Shuvosauridae indet. Indeed, Nesbitt (2007, p. 80) listed shuvosaurid (his Group X) specimens, including tibiae, from the same locality as MNA V5602 and V5603, but he did not provide specimen numbers or additional information.

MNA V5615 is a nearly complete right femur in two fragments (Fig. 4F-K). Kirby (1991) initially identified this specimen as cf. *Postosuchus* sp. However, based on the fibular groove opening at a nearly 90° angle and presence of a fibular condyle that is subangular, we assign this specimen to Shuvosauridae indet. (following Parker and Irmis, 2005).

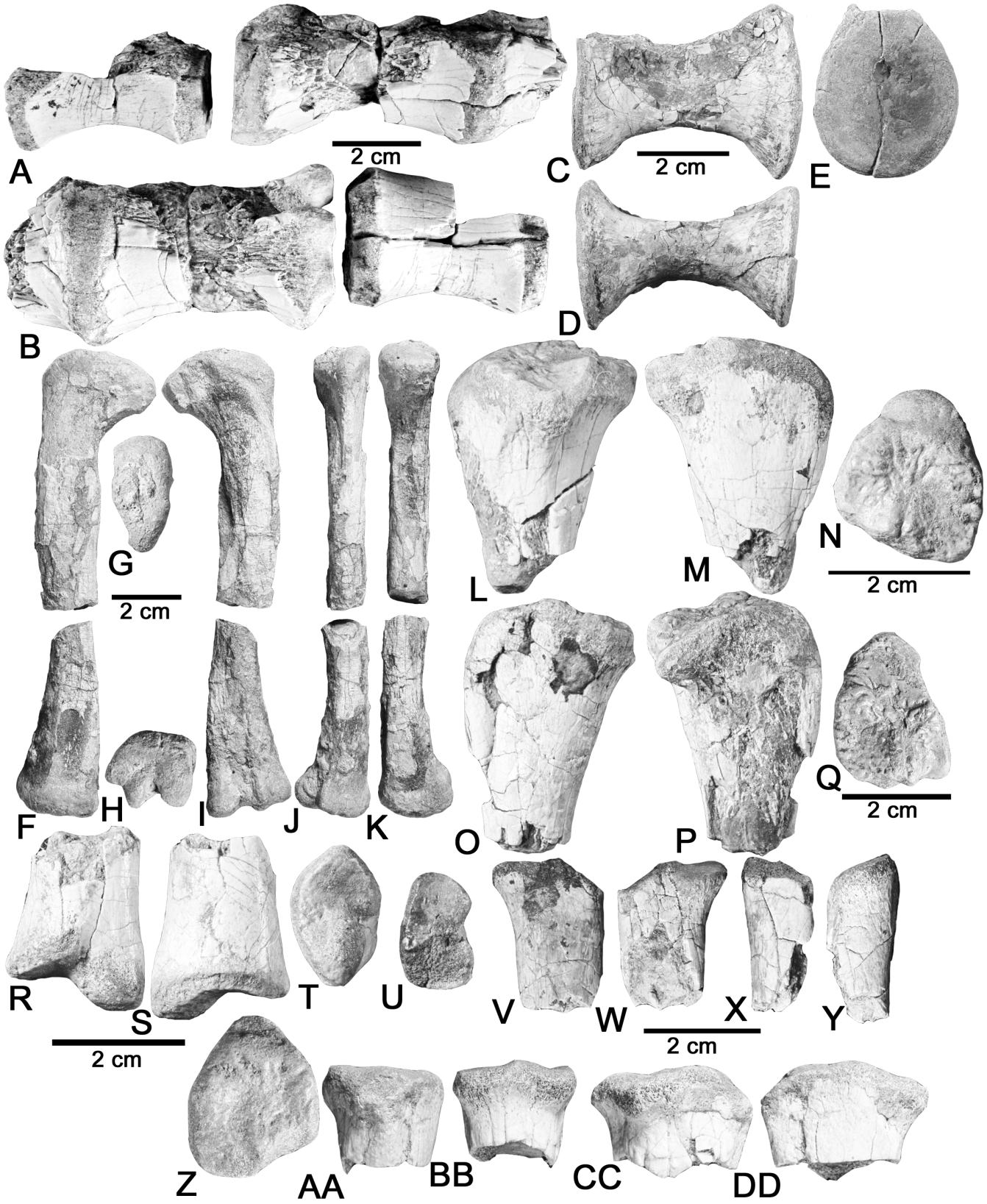

FIGURE 4. **A-B**, MNA V6731, Archosauria indet., three incomplete sacral centra in **A**, lateral and **B**, ventral views. **C-E**, MNA V4763, Parasuchidae indet., anterior caudal centrum in **C**, right lateral, **D**, ventral and **E**, anterior views. **F-K**, MNA V5615, Shuvosauridae indet., nearly complete right femur in two fragments in **F**, anterior, **G**, proximal, **H**, distal, **I**, posterior, **J**, lateral and **K**, medial views. **L-N**, MNA V5602, Shuvosauridae indet., proximal right tibia fragment in **L**, anterior?, **M**, posterior? and **N**, proximal views. **O-Q**, MNA V5601, Archosauromorpha indet., proximal left? tibia fragment in **O**, anterior?, **P**, posterior? and **Q**, proximal views. **R-T**, MNA V5605, cf. *Poposaurus* sp., distal left tibia in **R**, posterior, **S**, anterior and **T**, distal views. **U-Y**, MNA V5604, *Postosuchus* sp., proximal left tibia fragment in **U**, proximal, **V**, medial, **W**, lateral, **X**, anterior and **Y**, posterior views. **Z-DD**, MNA 5603, Shuvosaurid?, proximal left tibia fragment in **Z**, proximal, **AA**, medial?, **BB**, lateral?, **CC**, anterior? and **DD**, posterior? views.

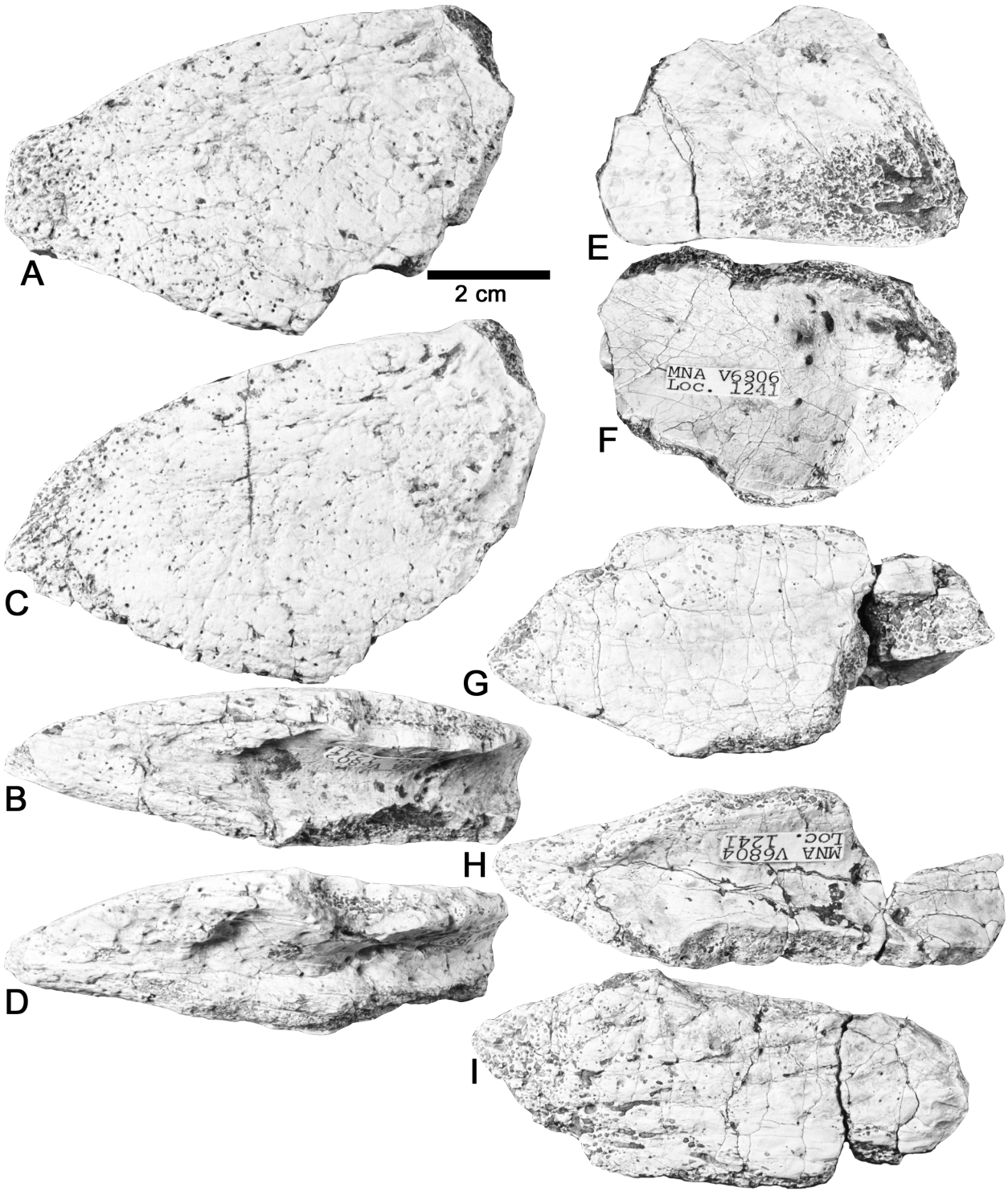

FIGURE 5. **A-D**, MNA V6802, *Typothorax coccinarum*, pair of left lateral osteoderms in **A**, **C**, dorsal and **B**, **D**, posterior views. **E-F**, MNA V6806, *Typothorax coccinarum*, right lateral osteoderm in **E**, dorsal and **F**, posterior views. **G-I**, MNA V6804, *Typothorax coccinarum*, left lateral osteoderm in **G**, dorsal, **H**, posterior and **I**, ventral views.

STAGONOLEPIDIDAE

Typothorax coccinarum

Kirby (1991) assigned numerous osteoderms, a thoracic rib, an incomplete centrum and an incomplete astragalus to the aetosaur *Typothorax coccinarum* based on the osteoderm morphology. Given the slightly arched nature of the paramedian osteoderms and their random, densely pitted ornamentation with prominent transverse ventral keels, along with the dorsoventrally compressed lateral osteoderms (Fig. 5) that are acutely folded into a laterally directed point, we concur. These specimens clearly pertain to *T. coccinarum* and not to *T. antiquum* (Lucas et al., 2002) or to any of the known species of *Redondasuchus* (Hunt and Lucas, 1991; Heckert et al., 1996; Spielmann et al., 2006). These specimens are important in that they corroborate a Revueltian age for the Owl Rock Formation, as first indicated by Lucas (1993; Lucas and Hunt, 1993).

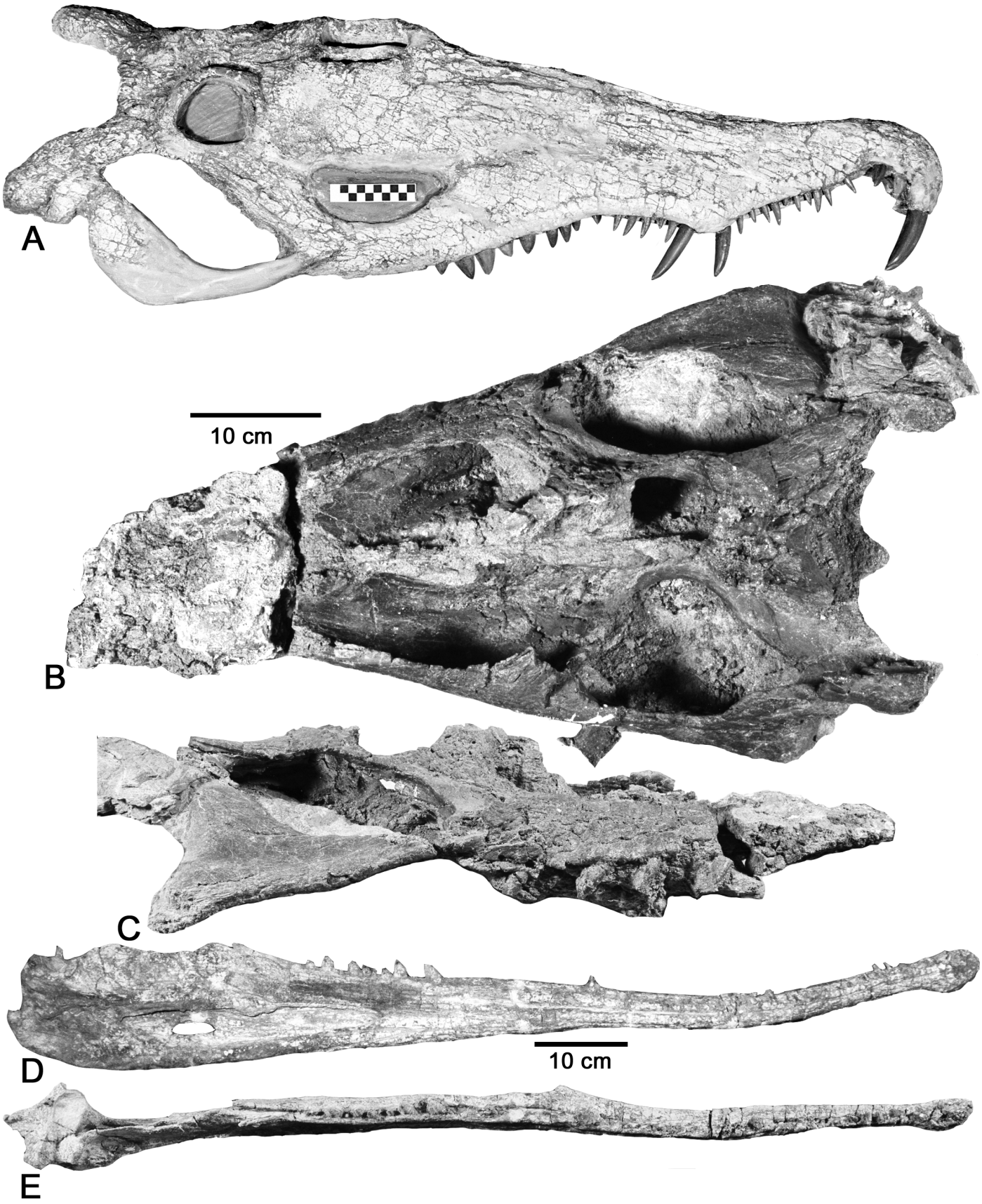

FIGURE 6. **A**, MNA V3478, *Pseudopalatus buceros*, male skull in right lateral view. **B-C**, MNA V3478, *Pseudopalatus buceros*, skull in **B**, dorsal and **C**, right lateral views. **D-E**, MNA number unknown (on display), *Pseudopalatus buceros*, left lower jaw in **D**, medial and **E**, occlusal views.

FIGURE 7. **A-B**, MNA V1983, *Pseudopalatus buceros*, posterior skull in **A**, dorsal and **B**, left lateral views.

PARASUCHIDAE
Parasuchidae indet.

Kirby (1991) identified MNA V4763 as a vertebra of cf. *Postosuchus* sp. However, the vertebra is extremely waisted, giving it an hourglass-shape in ventral view, and it lacks the prominent ventral lips on the anterior and posterior articular surfaces of the centra that are seen in *Postosuchus* (compare Fig. 4C-E to Long and Murry, 1995, fig. 130). This morphology more closely resembles an anterior caudal vertebra of a phytosaur than it does *Postosuchus*, so we assign this specimen to Parasuchidae indet.

Pseudopalatus buceros

As noted by Kirby (1991, p. 291), phytosaurs are the "dominant component of [the] Ward Terrace vertebrate [fauna]…at all localities." All of the phytosaur fossils were assigned to either *Pseudopalatus pristinus*, *Pseudopalatus* cf. *P. buceros* or cf. *Pseudopalatus*? sp. by Kirby (1991). We reassign all the phytosaur material from the Ward Terrace localities that is identifiable to the specific level to *Pseudopalatus buceros*. In addition, Kirby (1991) found evidence for five individuals based on cranial material; we revise this assessment, counting at least six individuals from the Ward Terrace sample.

Kirby (1991) identified most of the phytosaur cranial material he examined as *P. pristinus*, with the exception of a complete skull with a rostral crest (MNA V3478) that he identified as *Pseudopalatus* cf. *P. buceros*. Providing no detailed diagnosis for either *P. buceros* or *P. pristinus*, Kirby (1991) simply assigned phytosaur skulls lacking a rostral crest to *P. pristinus* and the one skull possessing a rostral crest (MNA V3478) to *Pseudopalatus* cf. *P. buceros*. The unassociated phytosaur postcrania were assigned to cf. *Pseudopalatus*? sp.

Curiously, a few of the specimens that Kirby (1991) assigned to *P. pristinus* do not have the rostral portion of their skull preserved. For example, MNA V3478, which is not included in Kirby's (1991) list of referred specimens, is a large, incomplete phytosaur skull preserving much of the skull posterior to the anterior margin of the antorbital fenestra (Fig. 6B-C). Unfortunately, the rostral portion of the skull anterior to the antorbital fenestrae is not preserved. This is also the case with MNA V1983, listed as *P. pristinus* in Kirby's (1991) referred specimens; it is the left posterior portion of a skull, and nothing anterior to the nares is preserved (Fig. 7). Again, in MNA V1595, a large fragment of the left posterior portion of the skull, nothing anterior to the orbit is preserved (Fig. 8B).

While a variety of diagnoses exist in the literature for *Pseudopalatus* (Ballew, 1989; Kirby, 1991; Long and Murry, 1995; Hungerbühler, 2002; Zeigler et al., 2002), the features that are generally agreed upon as diagnostic of the genus are: squamosal bars are usually prominently sculptured; supratemporal fenestra are short and narrow in dorsal view with narrow anterior margins; medial expansion of the squamosal bar narrows the transverse diameter of the supratemporal fenestrae; external nares are even with or raised above the level of skull roof; squamosal compressed with no rounded posterior process; supratemporal fenestra partially concealed in dorsal view; no fully crested rostrum; dentition weakly heterodont to homodont; and anterior end of snout is downturned with a constriction just posterior to the anterior margin. All the phytosaur skulls from the Owl Rock Formation clearly possess characteristics of *Pseudopalatus*.

Zeigler et al. (2002, 2003) posited sexual dimorphism in *Pseudopalatus* based on the prominent rostral crest of some specimens being a sexual display device. As explicitly stated by Zeigler et al. (2002, 2003) in their abstracts (though not in the text), the implication of their study is that *Pseudopalatus pristinus*, the "species" lacking the rostral crest, is the probable female morph, and *P. buceros*, possessing a prominent rostral crest, is the likely male morph. Thus, these two species should be synonymized into a single, sexually dimorphic species. Given that *P. buceros* (Cope, 1881) has priority over *P. pristinus* (Mehl, 1928), the result is that *P. pristinus* becomes a junior subjective synonym of *P. buceros*. Thus, all of the phytosaur material from the Owl Rock Formation is assigned to *P. buceros*, with one male skull (MNA V3478) (Fig. 6A), one female skull (MNA V3495) (Fig. 8C-F) and four skulls that are too incomplete to assign to either gender with confidence (MNA V1595, V1983, V3478, V3498) (Figs. 6B-C, 7, 8A-B). This follows figure captions for MNA V3478 and V3495 in Heckert et al. (2005), in which they also identify the skulls as male and female morphs, respectively, of *P. buceros*. The six skulls listed above are represented by distinct elements, most notably the posterior left portion of the skulls, so each represents a single individual. This differs from Kirby's (1991) assessment, which identified only five individuals based on cranial elements, although MNA 3478 is not listed in Kirby's referred specimens, so there is no evidence he saw or was aware of this specimen.

Kirby (1991) briefly described a collection of phytosaur postcrania from the Owl Rock Formation. Most of the specimens in this collection consist of various limb elements (Figs. 9C-F, 11), including paired femora (Fig. 11), as well as some lower jaws (Fig. 6D-E), girdle elements (Figs. 9A-B,10), vertebrae and dermal armor. Phytosaur taxonomy is based almost exclusively on cranial characters (Long and Murry, 1995; Hungerbühler, 2002), so isolated or associated postcrania are rarely assigned to a generic or specific level (but see Camp, 1930; Hunt, 1994). However, given that only *Pseudopalatus buceros* skulls were collected from the Owl Rock localities, we assign the postcrania to *Pseudopalatus buceros* based on their association with more diagnostic material. *Pseudopalatus buceros* is an index taxon of the Revueltian LVF, and is known from older Revueltian strata (e.g., Painted Desert Member of the Petrified Forest Formation) and cements a Revueltian age for the Owl Rock fauna.

SPHENOSUCHIA
Sphenosuchia indet.

Kirby (1991) illustrated and described vertebral centra and isolated teeth that he assigned to sphenosuchidae indet. During our examination of the MNA collection, we did not find, and thus could not examine these centra. However, based on the illustrations of Kirby (1991) these centra do appear waisted as are sphenosuchian centra. Thus, we

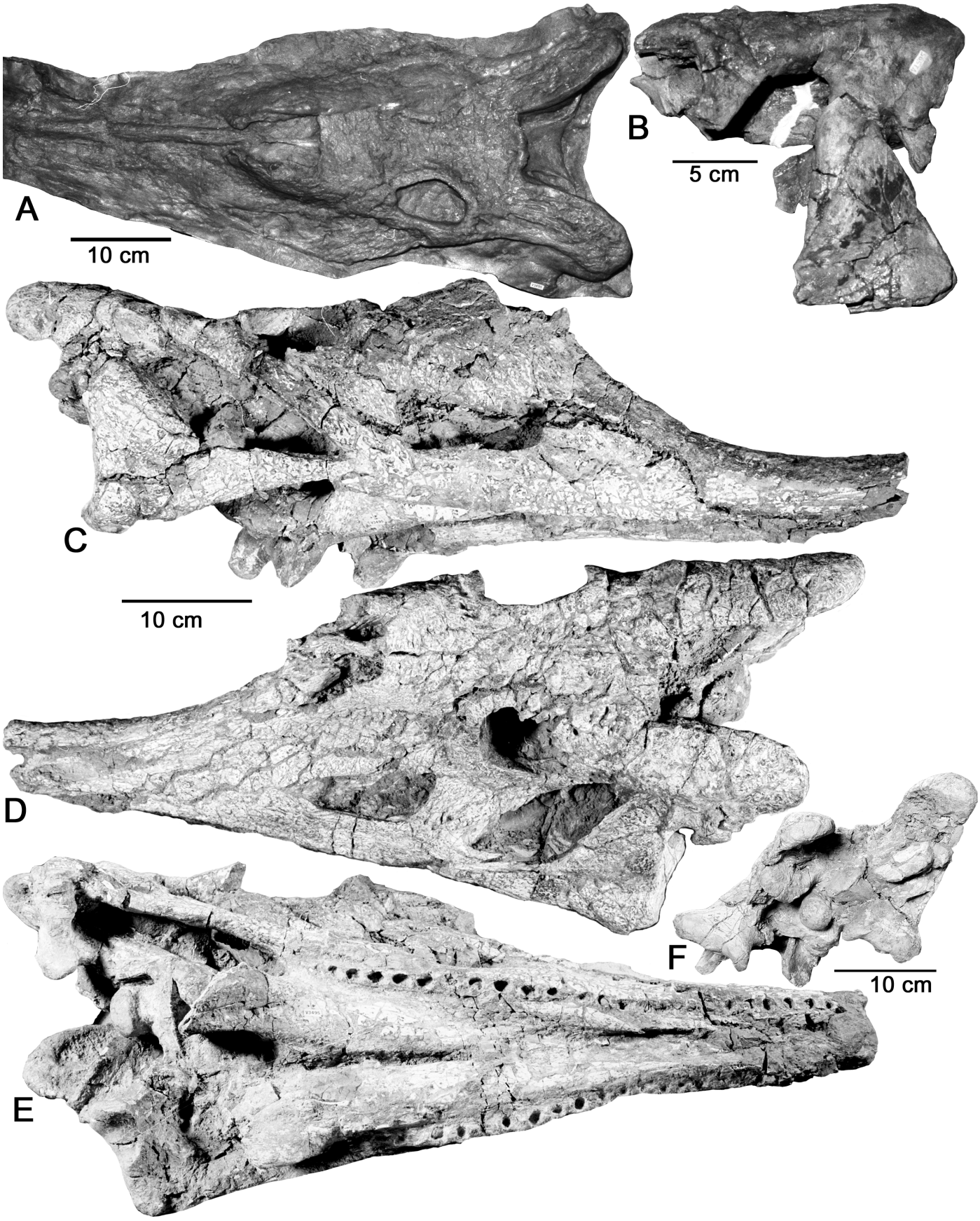

FIGURE 8. **A**, MNA V3498, *Pseudopalatus buceros*, cast of skull in dorsal view. **B**, MNA V1595, *Pseudopalatus buceros*, posterior part of skull in left lateral view. **C-E**, MNA V3495, *Pseudopalatus buceros*, female skull in **C**, right lateral, **D**, dorsolateral, **E**, ventral and **F**, posterior views.

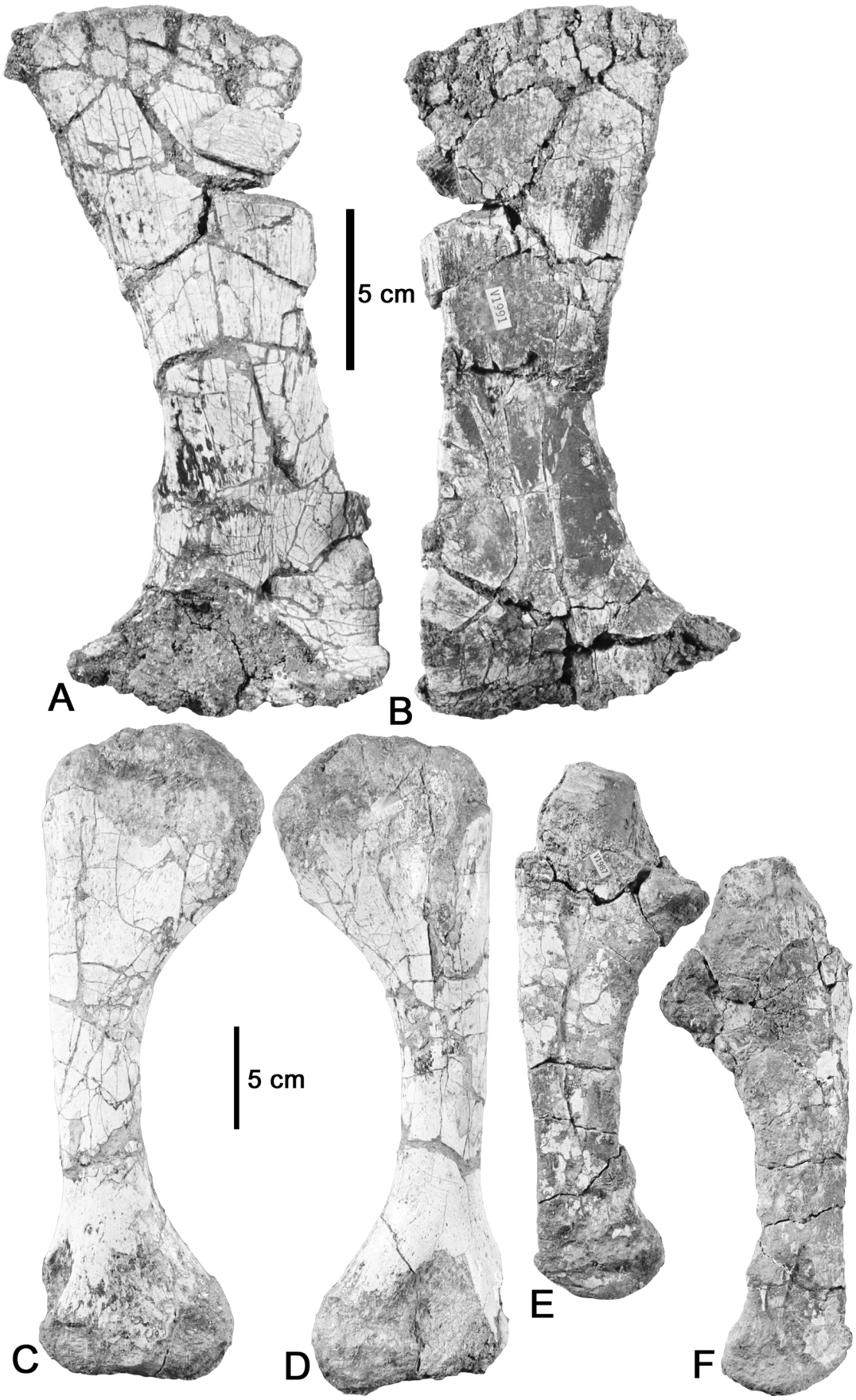

FIGURE 9. **A-B**, MNA V1991, *Pseudopalatus buceros*, right scapula in **A**, lateral and **B**, medial views. **C-D**, MNA V1596, *Pseudopalatus buceros*, left humerus in **C**, anterior and **D**, posterior views. **E-F**, MNA V1987, *Pseudopalatus buceros*, right ulna in **E**, anterior and **F**, posterior views.

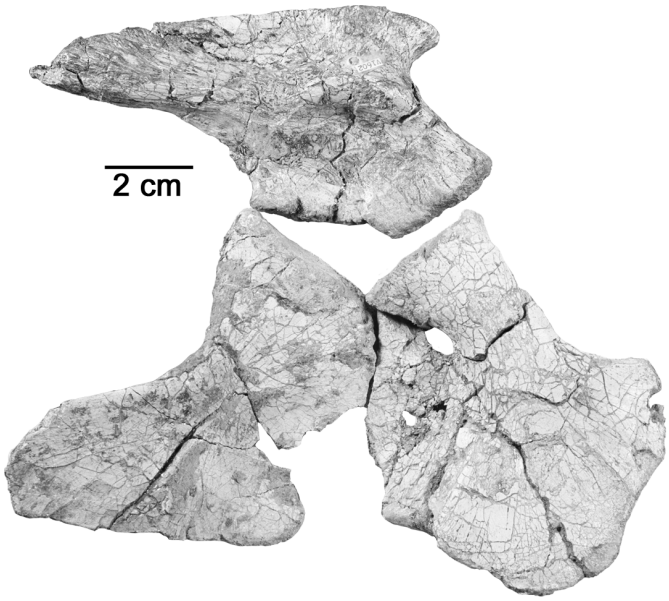

FIGURE 10. Reconstructed right pelvis of *Pseudopalatus buceros*, consisting of MNA V7903, right pubis, MNA V7904, right ischium and MNA V1602, right ilium.

consider this record legitimate. The teeth Kirby (1991) assigned as sphenosuchid are mediolaterally compressed and recurved, but this is a common feature of basal theropods, as well as suchian reptiles, thus these teeth should be considered Archosauromorpha indet.

DINOSAURIA
THEROPODA
Coelophysoidea indet.

A single proximal right femur (MNA V7240) in the MNA collection was labeled as *Coelophysis* sp. (Fig. 3I-K). This specimen is discussed by Kirby (1991) as Ceratosauria?, and Kirby (1993) records putative theropod specimens from the Owl Rock Formation. The femur has a "hooked" femoral head and a prominent trochanteric shelf, characteristic of the Coeolophysoidea. However, the specimen also appears pathologic, given the fine, pustulose bone texture on the trochanteric shelf that is not seen in other coelophysoid specimens and obscures the fine morphology of this feature. Thus, given our inability to further discern this specimen's morphology we assign it to Coelophysoidea indet.

DISCUSSION

Our revision of the Owl Rock tetrapod fauna from the Ward Terrace area provides an update to the previous interpretations of Kirby. As summarized in Table 1, several taxa have been split into additional taxa, some of which were not previously recognized from the Owl Rock Formation, while a few have been collapsed congruent with current taxonomic thinking and nomenclature (e.g., *Pseudopalatus*). The revised Owl Rock faunal list confirms the Revueltian age of the assemblage advocated previously (e.g., Heckert et al., 2005). Thus, the presence of *Pseudopalatus*

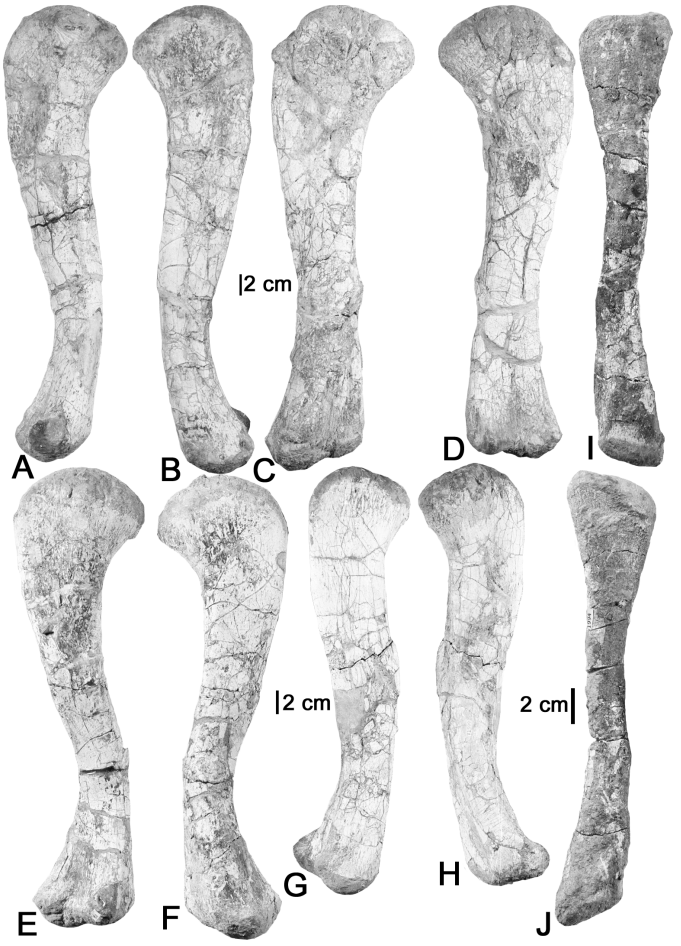

FIGURE 11. **A-B**, MNA V1598, *Pseudopalatus buceros*, left femur in **A**, posterior and **B**, anterior views. **C-D**, MNA 1597, *Pseudopalatus buceros*, right femur in **C**, anterior and **D**, posterior views. **E-F**, MNA V1600, *Pseudopalatus buceros*, left femur in **E**, posterior and **F**, anterior views. **G-H**, MNA 1599, *Pseudopalatus buceros*, left femur in **G**, anterior and **H**, posterior views. **I-J**, MNA V1994, *Pseudopalatus buceros*, left? fibula in **I**, medial and **J**, lateral views.

and *Typothorax coccinarum*, two index taxa of the Revueltian LVF, justify recognition of the Owl Rock tetrapod assemblage as the stratigraphically highest, and thus youngest, Revueltian assemblage in Arizona. Given that the Owl Rock Formation clearly overlies the Black Forest Bed in Petrified Forest National Park (e.g., Heckert and Lucas, 2002) and that the Black Forest Bed has been dated as less than 214 Ma (perhaps as young as 211 Ma) (Riggs et al., 2003), this indicates that the Revueltian extended from well before 214 Ma until well after 210 Ma, because Owl Rock deposition clearly took place over several million years (Tanner, 2000; Tanner and Lucas, 2007).

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TABLE 1. Comparison of the Owl Rock fauna as reported by Kirby (1993) and the revised faunal list advocated here, with principal taxonomic changes noted.

Faunal list of Kirby (1993)	Principal taxonomic changes	Revised faunal list
Amphibia Metoposauridae cf. *Metoposaurus* sp. A cf. *Metoposaurus* sp. B **Reptilia** Procolophonidae Kuhneosauridae Sphenodontidae Trilophosauridae *Trilophosaurus* cf. *buettneri* cf. Rhynchosauridae? Poposauridae? cf. *Postosuchus* sp. cf. *Chatterjeea* sp. Stagonolepididae *Typothorax coccinarum* Phytosauridae *Pseudopalatus pristinus* *Pseudopalatus* cf. *mccauleyi* cf. *Pseudopalatus*? sp. Sphenosuchidae? cf. Staurikosauridae? Theropoda cf. Ornithischia?	cf. *Metoposaurus* sp. A, cf. *Metoposaurus* sp. B → Metoposauridae indet., cf. *Buettneria*, *Apachesaurus* sp. *Trilophosaurus* cf. *buettneri* → Procolophonidae indet., Archosauromorpha indet. cf. *Postosuchus* sp. → cf. *Postosuchus* sp., *Postosuchus* sp., cf. *Poposaurus* sp., Shuvosauridae indet., Parasuchidae indet. *Pseudopalatus pristinus*, *Pseudopalatus* cf. *mccauleyi*, cf. *Pseudopalatus*? sp. → *Pseudopalatus buceros* cf. Staurikosauridae? → Archosauromorpha indet. Theropoda → Coelophysoidea indet. cf. Ornithischia? → Archosauromorpha indet.	**Amphibia** Metoposauridae Metoposauridae indet. cf. *Buettneria* *Apachesaurus* sp. **Reptilia** Procolophonidae indet. Kuhneosauridae indet. Sphenodontidae indet. cf. Rhynchosauridae? Suchians cf. *Postosuchus* sp. *Postosuchus* sp. cf. *Poposaurus* sp. Shuvosauridae indet. Stagonolepididae *Typothorax coccinarum* Phytosauridae *Pseudopalatus buceros* Sphenosuchidae? Coelophysoidea indet.

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